South Plateau Timber and Fuels Project

Soils Effects Analysis

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Issue 1: The cumulative effects of pre-existing detrimental soil disturbance (DSD) from past management activities plus potential new DSD likely to result from of some currently proposed timber harvesting activities may potentially exceed the Region One 15% maximum detrimental soil disturbance standards. In addition, the NEPA analysis for the South Plateau area has been conducted under revised NEPA direction requiring the field analysis been conducted prior to establishment of treatment unit boundaries, either mapped or identified in the field beyond identifying the general area of management activity. This approach would add additional uncertainty if standard soil DSD monitoring procedures were followed. *Detrimental soil disturbance is defined as: Adverse effects to soil quality caused by ground disturbing management activities, including: soil compaction, rutting, soil displacement, severe burning, surface erosion, activity caused soil mass movement, severe burning, and the loss of surface organic matter, lasting beyond the project period (USFS-R1 1999).*

Resolution 1: A conditional soils analysis has been used for the South Plateau area targeting those combinations of past harvest activities and currently proposed treatment options most likely to cumulatively exceed the 15% DSD standard. This analysis included inputs from: pre-implementation soil field sampling in the South Plateau project area, past management activity (FACTS) data, archived aerial photographs, and post-harvest soil monitoring from the adjacent Rendezvous Trail Timber Sale to project area inform the current analysis. The approach used could be considered as a worst case scenario to ensure treatments used will comply with the Region One detrimental soil disturbance standards, with constraints placed the proposed management activities, as needed, to ensure compliance. With the Region 1 Soil Quality Standards.

Issue 2: Some currently proposed vegetation management activities for the South Plateau Project have the potential to create concentrated areas of permanent soil impairment that, in the absence of appropriate soil restoration, would reduce land productivity in violation of the National Forest Management Act of 1976 and other legal mandates. Unlike detrimental soil disturbance, concentrated areas of permanent soil impairment covering a substantial area, are not covered by the DSD Standards and if created are also not covered by the existing exclusions from the DSD standards (USFS-R1, 1999). Permanent Soil Impairment is defined as: Detrimental changes in soil properties (physical, chemical, or biological) that result in the loss of inherent ecological capacity or hydrologic function of the soil resource that lasts beyond a silvicultural rotation or land management planning period USFS-WO 2009).

Resolution 2: Ongoing research being conducted on the Custer Gallatin National Forest, in collaboration with the Southern Rocky Mountain Research Station and Colorado State University has helped pinpoint the primary source or sources of land restoration problems associated with large burn pile footprints associated with large slash piles. In conjunction, the Forest has been developing multiple restoration strategies based in removing accumulated wood ash from portions of the largest burn pile footprints shortly after pile burning. The approach used is expected, based on preliminary results, to be both effective and efficiently implemented using either by hand or using small ground-based mechanical equipment.

Indicators:

1) Detrimental soil disturbance (DSD) levels within timber harvest units are maintained below the Region One maximum allowable level of 15% DSD for new management activities after all timber harvesting, mitigation and site restoration activities have been completed as well as the cumulative effects of new management caused plus pre-existing ground disturbance caused past management activities, thereby ensuring compliance with the R-1 soil quality standards.

2) Areas of "permanent soil impairment" caused specifically by the burning of especially large slash piles are not created as a result of proposed timber harvesting activities or if created are effectively mitigated using appropriate soil restoration procedures.

Affected Environment:

A wide range of soils, landscapes, geology, and vegetation types exist within the full South Plateau project area. Not all of these are discussed here in the current Affected Environment Section of this document. The areas covered in this report include all portions of the South Plateau project area where potential treatment unit boundaries have been identified within Plateau Bear Management Unit (BMU) and are slated of timber harvesting during the first year of project implementation. Details of other soil-landscapes, occurring primarily in perimeter portions of the project area, cannot be treated during the first year of project implementation due to timing issues for secure grizzly bear hiding cover. Details of the Affected Environment for those portions of the of the project will be discussed in a separate supplemental document, prior to the initiation management activities once in those areas, once sufficient field sampling has been completed to fully vet preliminary results.

Plateau Bear Management Area (BMU)

Landforms within the Plateau BMU consist primarily of lava flows originating from the Yellowstone Caldera. From a geologic perspective, they are quite young, having been formed during the Quaternary Period. (MBMG 2002). For the most part the volcanic flow paths cross the area along a northwest to southeast direction and for the most part remained largely intact, resisting the forces of erosion except where they are dissected by several drainages. The largest of these is the South Madison River that flows along the along the East boundary of the Plateau BMU. The underlying, surficial bedrock is mainly welded ash-flow tuff which identified by the Montana Bureau of Geology bedrock geology map as belonging to the upper member of the Lava Creek Formation (MBMG 2002). Field sampling throughout the Plateau

BMU has found, however, that the surface volcanic tuff is underlain in portions of the area at relatively shallow depths by either rhyolite bedrock or in other places by basalt bedrock at relatively shallow depths. These underlying extrusive, volcanic materials likely played a role in welding the lower portion of what likely had been a deeper, volcanic ash layer at the surface into welded tuff. Slopes along the flow paths range from 4 to 15% while escarpments formed by the downcutting of flowing water are much steeper with ranging in steepness from 25 to 60% slope.

Soil along the flow paths fall within the ashy particle size classification in Soil Taxonomy and are almost exclusively slightly weathered of volcanic ash, comprised of tiny shards of volcanic glass. The lack of rock fragments in surface soil horizons, uniform particle size distributions and limited amounts of clay in the soil all contribute to a high potential for water erosion to occur on any sustained grades steeper than about 15%. Thus, excluding large burn pile footprints, the primary threats to soils from traditional timber harvesting practices on these relic volcanic flow paths are soil displacement and the potential accelerated soil erosion to occur on sustained grade slopes steeper than about 15% along skid trails.

Particle size classifications on the much steeper escarpments are primarily ashy-skeletal with abundant channers, stones, and boulders, originating mainly from local rhyolite and welded tuff bedrock and much of the residual fine earth fraction primarily formed from the weathering of volcanic bedrock. Soil particle size classes along the escarpments range from very stony, sandy loams to extremely stony, loamy coarse sand, weathering of volcanic bedrock. Although volcanic ash initially would have blanketed nearly all portions of this area, much that that volcanic along the ecscarpments has likely washed downslope over time during heavy rains into the into the drainages below and occasionally washing out of those drainages altogether during spring floods.

Soil depths are predominantly very shallow to shallow (2 to 12 inches) along the steeper escarpments and shallow to moderately deep (14 to 38 inches) along on the flow paths based on the field sampling conducted. Even small areas of moderately convex slopes, found along portion of the flow paths, can have very shallow soils with approximate soil depths of 4 to 12 inches. As a result, the areas of moderately convex slope, even along should the flow paths should be avoided where practical during timber harvesting as such low productivity portions of the landscape once cleared in lodgepole pine areas will likely come back as densely packed, doghair stands of lodgepole pine.

Although soil compaction has been commonly cited a source of detrimental soil disturbance in volcanic ash soils (RMRS 2007) soil compaction does not appear to be a major issue in the ashy soils of South Plateau. For several reasons, volcanic ash in the South Plateau area is coarser textured than most volcanic ash deposits found elsewhere in the Pacific Northwest. One reason is the source area from which volcanic ash in the South Plateau area originated, the Yellowstone Caldara. Most other surficial volcanic ash deposits in Montana, Idaho, eastern Washington and eastern Oregon, where surface volcanic ash is encountered at the mineral soil surface, have ash from Mount Mazama.

The second reason for coarser textured volcanic ash deposits s in the South Plateau area is the young age of the material deposited, essentially current ash deposition from a geologic standpoint. Since younger, volcanic ash in the South Plateau area is both less weathered and has been less enriched with nutrients from other finer grained aeolian sources such as loess. As a result, volcanic ash in the South Plateau area is coarser textured, less fertile, less prone to compaction, potentially more prone to water erosion and

lacks the typical orange tinge or hue that can be used elsewhere, at least in Montana and Idaho, to verify the presence of volcanic ash caps.

Note: *The same landforms and soils dominating the South Plateau area are prevalent in the adjacent Rendezvous Trail area to the east (minus the escarpments) and extend well into Yellowstone National Park, both to the south and to the east.*

Methods

Field Procedures: A combination of sampling techniques were used to assess pre-existing levels of DSD within the South Plateau project area. These include direct measurements taken along traverses, point sampling, transect sampling by past activity type, and field reconnaissance sampling. All the above, were used to assess preliminary levels of pre-existing DSD by past activity/harvest type. Although each approach has a slightly different function in the assessment of DSD levels, they all contributed to a better overall understanding of local soil resource conditions within the project area, primary soil formation and landscape processes that affect the local soil resource's resilience as well as vulnerabilities to various types of ground disturbance. Of paramount importance is understanding how local soil and site conditions contribute to the spatial variability and distribution of local plant communities where vegetation management activities have occurred in the past and are currently being planned. By using multiple sampling strategies, the approach used enables cross checking amount different sampling strategies, helping to ensure the accuracy and consistency of field results.

Changes in Standard Field Analysis Procedures: The primary change in the NEPA analysis for South Plateau project and presumably other vegetation management projects going forward is the lack of prior knowledge about the size, location and positioning and details of the type or types management activity likely to occur on any given parcel of land. Previously, for the past 15 plus years, all of the above information would have been provided, at least in a preliminary version at start and certainly before completion of the NEPA analysis process. Although changes may have occurred in along the way or treatment units dropped, having that information at the start enabled field scientists to target their field work to proposed management activity areas, making efficient use of limited field from the onset of field sampling. There was a clear vision from the start of what needed to be sampled, in one fashion or another.

For South Plateau and potentially other vegetation management projects going forward, much of that information was not known until nearly the end of field sampling period for Priority Area One. Thus, the focus of field sampling had to be adjusted. Instead of focusing on proposed treatment units, sampling for South Plateau has been focused more on past management activities, such as clearcutting or commercial thinning, within a specific soil-landscape area, in this case the Plateau Bear Management Area, resulting in more of a probability approach to predicting future, soil disturbance results. The analysis results for phase one in the South Plateau

area are therefore not no longer based on site specific sampling of known treatment units but based on a series of condition statements, such as: if clearcutting in conducted in this soil-landscape area, under these conditions, the expected result will be… The approach places a much greater emphasis on verifying analysis predictions after all management activities have been completed than making detailed predictions of likely post treatment DSD levels within known treatment units at the start. Each of the two contrasting approaches, has its own pluses and minuses. It remains to be seen, however, if the current new approach will prove to be more efficient or not and at what cost. The revised approach is certainly more complicated.

To expedite the analysis step for South Plateau, most of the field analysis has been focused on those treatment combinations most likely to approach or exceed the Region One, maximum 15% DSD Standards. Treatment options with lower likelihood of approaching or exceeding the DSD threshold level, such as group selection or aspen treatments with lesser amounts of ground disturbance created, are not analyzed since it is sufficient to just know that those management activities conducted in areas limited pre-existing ground disturbance under specific constraints will not exceed the 15% standard, and less important to make a specific projections of expected DSD levels on an individual treatment unit by treatment unit basis. The conditional NEPA approach undoubtedly, shifts the burden of proof more towards to post-harvest field sampling rather than detailed, pre-activity sampling. Whether that streamlines the process or not remains to be seen. In any event, representative post-harvesting/post-activity DSD sampling will need to be conducted after implementation to ensure compliance within, new activity, treatment units.

DSD Assessments for Currently Proposed Management Activities

Unlike the pre-existing DSD analysis which has change dramatically under the revised NEPA approach, projections of expected DSD levels by proposed management activity largely unchanged from the methodology used previously. These projections are targeted at individual treatment units even though those units as-of-yet have not yet been completely identified. In a more broad-based fashion all potential treatment units can be analyzed for multiple treatment scenarios. That has been cumbersome the first time through, but subsequent analyses once the analysis steps are adequately programmed and the analysis hard-wired for multiple treatment alternatives and specific soil-landscape types could be run for all potential management alternatives in a short period of time. That should be the goal, in any event.

Once again, as per above, a systematic approach has been used, that focuses on those proposed treatment options having the greatest potential to create high levels for detrimental soil disturbance, or potentially exceed the 15% maximum DSD standard, either by direct effects or cumulatively in combination with specific past management activities.

For South Plateau, clearcutting and commercial thinning are the two potential vegetation treatment (harvest) options that potentially needed to be analyze. Other proposed treatments

options, such as non-commercial thinning, aspen treatments, prescribed burning, or partial harvests in Douglas-fir stands, have been shown elsewhere on the Forest to create only limited amounts of overall ground disturbance relative to the 15% DSD standard. Detailed analysis, therefore, was not required for those management options since post management activity results will be well below the DSD 15% threshold level unless exceptionally high levels of pre-existing DSD exist that would have been identified in the pre-activity analysis.

As for analyzing clearcutting versus commercial thinning, both these commercial harvest/treatment options could be comparable in terms of the level of DSD created. Average skid trail spacing associated with thinning would be closer than that for clearcutting but other disturbance vectors, such as the size of landing areas or burn pile footprints would be greater under clearcutting than commercial thinning, especially in those sites planned for clearcutting where commercial thinning had occurred about 40 to 60 years ago. Hence, the detrimental soil disturbance analysis was run for clearcutting based on the principle that if B is less than A and A is less than the standard, then B, commercial thinning in this case, will also be less than the standard.

As components of field sampling, archived aerial photographs covering the South Plateau area along with the available past activity (FACTS) data were utilized to help locate and identify sample area boundaries as well as informing the analysis where those areas with the highest likelihood of having high levels of past management activity-caused detrimental soil disturbance relative to the 15% standard were most likely to occur.

Resource Indicators and Measures

- Projected levels of detrimental soil disturbance (DSD) likely to occur as a direct result of the proposed management actions and cumulatively with regard to the combined effects of pre-existing plus new management activity caused detrimental soil disturbance.

- The size and overall extent of burn piles within treatment units resulting from the proposed management activities, as well as, the extent and likely effectiveness of restoration actions to be used for returning burn pile footprints to a productive state. Target levels will be to treat 50 to 60% of the exposed burnpile area (defined as that portions of the total burn pile footprint where the ground surface is not covered by large, partially burned woody material that was consumed during pile burning) for those piles accessible by system roads. For those burn piles where access for re-entry with ground-based mechanical equipment is due to the closure of temporary roads prior to burning that percentage range is 20 to 30% of the exposed burn pile footprint. In both cases the areas of exposed mineral soil will be dispersed across the burn pile footprint.

- The extent and relative size of coarse woody material left behind in dispersed areas of timber harvesting at the completion of all timber harvest and mitigation activities.

Environmental Consequences

The effects of management activities, both past and currently proposed, on local soil and land resources are dependent on several variables. Paramount to the discussion is the type, amount, and severity of ground disturbance created by past management activities (pre-existing ground disturbance) and the type, amount, and severity of ground disturbance likely to be created by of currently proposed management activities. Of nearly equal importance, however, are inherent properties of local soil resource that determine the resiliency or vulnerability of the local soil resource to the specific types, extent, and severity of ground disturbances, either already pre-existing at a site or are likely to be created as a result of the currently proposed management actions.

No Action Alternative

Under the no action alternative, no commercial timber would be harvested in the South Plateau area. This would constitute a loss of potential revenue to adjacent communities and opportunity costs associated with of not being able utilize the available timber resources (mainly lodgepole pine) in the South Plateau area. There are also opportunity costs associated with not reducing potential fire hazards which without treatment will likely increase over time as the existing lodgepole pine stands mature further and start to degrade or degrade further depending on current stand conditions.

The likelihood for a major bark beetle infestation will also increase over time as the mostly pure lodgepole pine stands, with or without a subalpine fir understory, become more mature. These lodgepole pine stands, if not harvested or consumed by wildfire will eventually be replaced by non-merchantable subalpine fir that currently are present, in the understory over much of the area. While the eventual conversion from lodgepole pine to subalpine fir forests would increase hiding cover for wildlife but also increases the extent of ladder fuels, adding to the likelihood for extreme wildfire behavior to occur during dry conditions. Such conditions when present over large, contiguous area, such as South Plateau, represents an extreme wildfire hazards to the resource as well as safety concerns for community of West Yellowstone, the public at large, and most directly to firefighters who would be tasked to control those fires under potentially very hazardous conditions.

From a Soils perspective, however, the No Action Alternative likely has fewer potential risks to the long-term viability of soil resources in the area, than the currently proposed Action Alternative. This is primarily due to a level of uncertainty regarding the Forest's commitment to

complete restoration of large burn pile footprints associated with whole tree yarding after pile burning has been completed, given current restrictions on available manpower and funding.

While severe burning during wildland fires does have the potential to create degraded soil conditions, in most instances, areas burned recover naturally so long as fuel loading over large, contiguous areas has not reached critical threshold levels. In contrast, when much of the surrounding forest's biomass is concentrated in a series of very large slash piles and burned there, numerous changes occur at the surface and in the underlying soil resource making site restoration somewhat challenging, but more so, making natural recovery of the burn pile footprint highly improbable and likely impossible over a human lifetime. Thus, tradeoffs exist within the proposed action alternative between the resource protection costs and potential to create adverse effects to soil resources.

Proposed Action Alternative

Direct and Indirect Effects of the Proposed Action

The proposed action alternative has, many beneficial aspects, with respect to public health and safety, reduction of wildfire threats, preventing or minimizing potential mountain pine beetle outbreaks, utilizing the available timber resource, and providing economic benefit to the local community. Some level of ground disturbance will be created, however, due to the proposed management alternative, including detrimental soil disturbance and potentially, permanent soil disturbance. new detrimental soil disturbance will be created as a result of the proposed management alternative, and potentially "permanent soil impairment" could be created that results in a long-term loss of inherent land productivity.

Direct Effects to soil resources are those ground disturbances, including chemical, physical and/or biological changes to the soil resource that are caused by management activities that reduce the productive potential of the land. Relative to proposed timber harvesting in the South Plateau area, direct effects to soil resources will be created during timber harvesting, processing, and hauling as well as the disposition of non-merchantable woody material. A classic example of a direct effect would be soil compaction caused by of heavy ground-based equipment operating within treatment units.

Although some direct effects are inevitably associated with a timber harvesting, they are not all bad. It really depends on the type, extent, and severity of ground disturbance created whether the net effect whether the net effect on any given ground disturbance is potentially positive or adverse. For the assessment of ground disturbance, it is helpful to look at timber harvest units as a compilation of different activity areas, including: any temporary roads constructed, skid trails, dispersed timber harvesting areas, the timber processing portion of landings, and burn pile areas. Each of these areas after harvesting has been completed leave behind their own distinct

footprint on the ground. Thus, the type, extent, and severity of ground disturbance in dispersed timber harvesting areas is very different from that of the burn pile footprints that result from the burning of slash piles.

As a general rule, those ground disturbance areas of the greatest aerial extent, such as the area of dispersed timber harvesting or the donut area surrounding large burn piles at landings, often have the lowest levels of ground disturbance DSD on a per area basis. At the other extreme, are activity areas of limited extent, such as burn pile footprints or temporary roads which have the highest concentration of ground disturbance as well as highest severity of impact. It is this latter group that presents the greatest challenge for site restoration and has greatest likelihood of creating long-term, detrimental soil disturbance.

Table 1 and Table 2 below illustrates the variability in detrimental soil disturbance levels within a commercial timber harvesting unit by activity type. Each activity type encompasses a portion of individual treatment units where a specific management activity of combination of management activities occur. In a sense they represent sub-areas within individual treatment units such that the sum of all categories equals the total amount of DSD projected to result from the proposed management action, after being adjusted to account for any overlap between pre-existing detrimental soil disturbance and projected new detrimental soil disturbance (DSD).

Ground disturbance data used for these tables came from soil monitoring conducted after completion of timber harvesting in the adjacent Rendezvous Trail area, soil monitoring of pre-existing DSD levels in the South Plateau area by past harvest type, and more standard methods of making projections of ground disturbance levels likely to be created by management activity type, such as determining the amount of DSD likely to occur along skid trails based on activity type, average skid trail width, tire width, and average skid trail spacing. From a soil's perspective, ash capped soils in the Rendezvous Ski Trail area an ideal surrogate data set for ash capped soils in the South Plateau area as soils between the two areas are very similar, except for the fact that local landforms in the Rendezvous provide better protection from erosion in the Rendezvous area than volcanic flow paths in South Plateau.

Other data compiled from Rendezvous have also helped inform the analysis for South Plateau, such as the relationships among treatment unit size, burn pile size, and landing sizes. These have been used to condition expected soil disturbance results for South Plateau based on either treatment unit size or burn pile size. Date in Table 1 clearly shows that in order to ensure that the impact of clearcutting in ash will remain below the threshold 15% level after all treatment activities have been completed, the minimum treatment units size should be 10 acres or more in size, as prior to any restoration actions taken the average treatment unit DSD level is only 15.58% which likely can be reduced below the 15% standard using standard mitigation or restoration procedures even when moderate levels of prior DSD exist.

The same cannot be said, however, for treatment units of 10 acres or less in size, however, where direct effects are projected to result in a DSD level of 18.3 percent, before accounting for any prior DSD. These stands would have a high probability of exceeding the 15% DSD standard after implementation and would be rejected by the conditional NEPA results.

Table 1. Expected direct effects on treatment unit DSD levels from clearcutting in small (10 acres or less) treatment units in the South Plateau Area where whole tree yarding will be used, and volcanic ash capped soils are present. Proposed mitigation/restoration steps could likely reduce the direct effect down below the 15% DSD standard but there would be very limited space in the analysis to account for even minor amounts of pre-existing DSD.

Activity Area Type	Total Aerial Extent (ac.)	Initial Proportion. DSD	Total Area DSD (ac)	Total Basis Area (ac.)	Overall DSD% by Activity Area
Burn Pile Area Footprint	236	1.0	236	9,848	2.40%
Timber Processing	995	0.6	597	9,848	6.06%
Temp Roads	136	1.0	136	5,033	2.70%
Skid Trails	919	0.5	460	9,848	4.67%
Dispersed	7,562	0.03	227	9,848	2.30%
Totals	9,848	----	1,656	9,848	**18.13%**

Table #2. Expected direct effects on treatment unit DSD levels from clearcutting in moderate to moderately large (10 to 40 acres) treatment units with whole tree yarding in volcanic ash capped soils. Proposed mitigation/restoration actions can readily reduce the projected DSD levels below the maximum 15% DSD standard even with moderate levels of pre-existing DSD.

Activity Area Type	Total Aerial Extent (ac.)	Initial Prop. DSD	Total Area DSD	Total Basis Area (ac.)	DSD% by Activity Area
Burn Pile Footprint	197	1.0	197	9,848	2.0%
Timber Processing	581	0.6	349	9,848	3.54%
Temp Roads	136	1.0	136	5,033	2.70%
Skid Trails	968	0.5	484	9,848	4.91%
Dispersed	7,966	0.03	239	9,848	2.43%
Totals	9,848	---	1,405	9.848	**15.58**

The comparison between Tables 1 and 2 above, shows how directly restricting the minimum allowable treatment unit to 10 acres or large affects the ability to adequately amortize ground disturbance created by clearcutting along with a moderate level of pre-existing DSD, and potentially ground disturbance associated with a temporary road construction within the smallest treatment units. Prior to planning for whole-tree yarding (wty) 5 acres was the approximate minimum treatment unit size but with for wty the minimum size is closer to 10 acres in many instances. Alternative options are to use a less impactive silvicultural prescription, combining like treatment units or a combination of those two. One way or another, under the conditional NEPA process the Forest needs to show that the 15% DSD standard can be met in all treatment units carried forward. noted in the table above. Those preliminary results,

At the other end of the spectrum, large treatment units, in conjunction with whole tree yarding often result in excessively large burn piles. The burn pile footprint of such piles is that are extremely difficult to efficiently and effectively restore site back to a productive state. It becomes even more difficult in areas where ground based mechanical equipment cannot be used in burn pile restoration because temporary roads need to be closed prior to pile burning. Thus, an upper limit is proposed for the maximum allowable size of burn piles associated with whole tree yarding. Since burn pile data from the Rendezvous area clearly shows used treatment unit size and burn pile size are strongly correlated when whole tree yarding is used, the same result can be obtained in either direction; by directly limiting the maximum burn pile size or indirectly limiting burn pile size by effectively limiting the maximum allowable treatment unit size.

Results relative to the Region One DSD standards do not appear to be an issue for this project so long as commercial harvest treatment units remain larger than 10 acres in size. A bigger issue from the soil resource perspective are the large size of burn pile footprints and the potential for creating "permanent soil disturbance" as a result of burning of excessively large slash piles associated with whole-tree yarding, such that effective restoration actions needed cannot be completed in an efficient manner. Although a full discussion is outside the purview of this report, the excessively large burn piles create a separate problem associated with the analysis of soil disturbance data since they clearly fall outside the underlying assumption for nearly all statistical inference, that the sample data are independent and identically distributed (IID). While not an insurmountable issue, analytically the burn pile disturbance data would have to be treated separately from the detrimental soil disturbance data purely on analytical grounds. The bottom line is that the Forest cannot create permanent soil impairment and cannot reduce "the land's inherent ability to provide good and services to current and future generations of Americans" based on the law.

Thus, the application of an appropriate restoration strategy is needed to initially restore land productivity over portions of large burn pile footprints and by doing so demonstrate the ability to move toward eventual restoration on these sites. Details of procedures to be used are discussed briefly under Design Features in this report and covered in detail in the Management Approaches section portion of the Revised Forest Plan. They will also be included separate Technical Report going forward.

Indirect Effects: Direct effects to soil resources are those ground disturbances, including chemical and/or physical changes to the soil resource that reduces land productivity capacity of the land or the potential of the lathat to soil chemistry or changes to soil physical properties, reducing hydrologic function the ability of the soil effects of chemical and/or physical changes to the soil resource that reduce the productivity of land resources or impacts created by management activities in the course of harvesting, processing, or hauling timber, for example, soil compaction caused by the use of heavy ground-based equipment. Indirect effects while not directly created by the original management action are from a soils perspective most often related ground disturbances that were created by a management action are to a large degree caused by those initial ground disturbances. There are at least three types of indirect effects likely to occur to soil resources from timber harvesting activities in the South Plateau area. These include:

Accelerated Soil Erosion resulting from the initial ground disturbance, which might be skid trails are oriented in an up and down direction or overland flow whatever the source flowing water in a downhill in an unconfined channel. Any water flowing downhill or down slope has the potential to remove soil and create rill or gully erosion or rutting in a downslope direction. Design features that limit the use ground based heavy equipment on steep slopes (>40% sustained slopes) are designed to limit such soil erosion, as is the use of cross ripping on skid trails, or the incorporation of erosion control features along temporary roads as conditions warrant.

Potential Spread of Noxious Weeds: A second type of indirect adverse effects to soil resources is related to ground disturbances that expose mineral soil, either exposed mineral topsoil or exposed subsoil. disturbance s primarily is areas of exposed mineral soil along temporary roads, skid trails and on burn pile and/or landing areas by the types of management activities that occur in those areas and either create bare soil, either exposed topsoil or subsoil or poor quality soil conditions that favor weedy species. caused by management activities that in turn created favorable conditions for the spread of noxious weeds and/or annual weeds. In conducting initial field monitoring for the Rendezvous Trail Timber Sale, neither houndstongue or Canada thistle, the primary noxious weed species that thrive on old burn pile scars at lower elevation portions of the Forest, were observed. Thus, I assumed those noxious weed species were not competitive at higher elevations. That may be true anymore as recently Canada thistle was found in the Lonesome Wood project area, near the south shore of Hebgen Lake. This suggests conditions might be changing. Also, another weed species, hoary alyssum, recently added to the state noxious weed list, was found making headway spreading south along the National Snowmobile Trail and major summer access route into the South Plateau area from the north. Thus, the potential spread of noxious weeks as a result of ground disturbances associated with timber harvesting cannot be ruled out an indirect threat to soil resources.

Limited Coarse Woody Debris in Past Commercial Thinning Units:

Forest Plan direction for the South Plateau Project currently falls within the purview of the old Gallatin Forest Plan (1977?). Direction with respect to the old Forest Plan on for coarse woody debris comes from Amendment 15, the "Wildlife Snag Amendment" to leave 15 tons/acre CWD "where available" (2/93). More recent research on this topic strongly suggests that having sufficient coarse woody debris on the forest floor or buried in the soil and the ectomycorrhiza that CWD supports are both more valuable (not less) than initially thought with regard to the sustainability of conifers trees (Simard S. W. 2009; Wagner et. al. 1989; Perry 1995; Rierkerk and van de Kopple2008) especially on poor quality. Specific to pines, "the effects the effect of ectomycorrhiza on seedling establishment (growth and survival) is well documented (Smith and Read 2008); increased seedling growth is a common response to ectomycorrhiza. Also important is the effect ectomycorrhiza have on modifying host (pine) production of secondary chemistry,

such as the production of “monoterpenes” which “modifies host secondary chemistry and herbivore performance”, i.e. mountain pine beetle performance (Karst, et.al. 2015).

Past commercial thinning in now mature lodgepole pine stands largely cleaned out most of the existing CWD in these stands which are now 60+ years old. If clearcutting is the current silvicultural prescription for previously cleaned stand, then roughly 100 years will have passed since there have been any large pulses of coarse woody material were added to the lodgepole stands in the commercially thinned areas. This lack of coarse woody recruitment over an extended period may potentially have adverse effects on the sustainability on the next generation of lodgepole pines growing on marginally fertile infertile soils of the South Plateau area.

Cumulative Effects: Tables 4 and 5 below show results of the cumulative effects analysis for two treatment unit scenarios. The first of these is for treatment units where past commercial thinning occurred along with a substantial ground scarification conducted in the stand. This silvicultural prescription as well as clearcutting with substantial ground scarification appear to have been common treatment options used in the lodgepole pine stands of the South Plateau area at that time. Relative to Tables 1 and 2, these table addresses cumulative effects as pre-existing DSD levels from the past management activities plus new detrimental soil disturbance likely to occur as a result of currently proposed management activities. Overlap between the two ground disturbing activities (past and present) has been accounted for in the analysis.

Although some cumulative effects would likely exist between currently proposed, timber management activities and disturbance from pre-existing dispersed recreation disturbances, these would be of limited extent relative to the overlap of pre-existing and currently proposed timber management activities. In general, recreationist travel along trails and roads, while most timber management activities occur within treatment unit interiors.

***Table 3**. Projected cumulative effects on detrimental soil disturbance levels likely to result from proposed clearcutting in areas with moderate levels of pre-existing ground disturbance from the combined effects of prior commercial thinning with ground scarification for medium size (10–40 acre treatment unit size).*

Activity Area Type	Total Area x Activity Type (ac.)	Initial Prop. DSD	Total Area DSD (ac.)	Total Basis Area (ac.)	Overall DSD% by Source	Prior Adj. DSD Levels
Pre-existing DSD	9,848	0.04	394	9,848	4.0%	4.0%
Burn Pile Footprint	197	1.0	197	9,848	2.0%	2.0%
Timber Processing	581	0.6	348	9,848	3.53%	3.4%
Temporary Roads	136	1.0	136	5,033	2.7%	2.7%
Skid Trails	919	0.5	460	9,848	4.67%	4.5%
Dispersed	8,015	0.03	240	9.848	2.44%	2.3%
Totals	9,848	---	9,848	9.848	19.2	18.9

In each instance, the effect of pre-existing detrimental soil disturbance is muted somewhat by the overlap between pre-existing and new activity caused DSD. Mitigation and/or restoration effects on total DSD values has not been factored into the values presented. For prior commercial thinning with ground scarification and proposed treatment units within the 10 to 40 acre size range, standard mitigation actions will clearly get DSD levels within these treatment units below the maximum 15% DSD standards. The same cannot be said for those treatment units in areas where severe ground scarification was used for site preparation. In hindsight, it makes no sense to have scarified commercial sites when desired future stocking already existed in the stand and future levels pre-determined by the silvicultural prescription. In any event overly aggressive ground scarification added to the overall level of DSD, potentially limiting current management options in some locations.

Table 4. Projected cumulative effects on detrimental soil disturbance levels likely to result from proposed clearcutting in areas of excessive amounts of pre-existing ground disturbance from past commercial thinning with severe ground scarification.

Activity Area Type	Total Area x Activity Type (ac.)	Initial Prop. DSD	Total Area DSD (ac.)	Total Basis Area (ac.)	Overall DSD% by Source	Prior Adj. DSD Levels
Pre-existing DSD	9,848	0.06	591	9,848	6.0%	6.0%
Burn Pile Footprint	197	1.0	197	9,848	2.0%	2.0%
Timber Processing	581	0.6	394	9,848	4.0%	3.8%
Temporary Roads	136	1.0	136	5,033	2.7%	2.7%
Skid Trails	968	0.5	484	9,848	4.9%	4.7%
Dispersed	7,966	0.03	239	9,848	2.4%	2.1%
Totals	9,848	---	9,848	9.848	---	21.3%

Table 5 below provides an example of how initial DSD conditions are mitigated over time either due to the combined effects of Soils design features or post-harvest mitigations or more directly through direct restoration. Restoration effectiveness should be monitored over time verify desired results have been achieved. Initial implementation reviews can be used to determine if assumptions made in the original NEPA analysis were accurate, such as skid trail width or the proportion of DSD across skid trail corridors. At year two after implementation, monitoring would be used assess the effectiveness of mitigation or restoration actions taken to address the underlying source of sources of resource damage, such as the effectiveness of ripping soil compaction or effects on water infiltration or soil pH conditions. It is not until year five,

however, that long-term success of re-establishing desired native vegetation can be reasonably assessed from a long-term revegetation perspective and even longer time period to ensure that a positive trajectory exists for subsequent natural recovery.

Table S5. - Projected levels of DSD over time Based on an assumption of successful implementation of mitigations and design features as well as restoration actions if needed.

Activity Area Type	**Initial DSD Condition**	**Effect Year 2**	**Effect by Year 5**	**Initial DSD Levels**	**Year 2 DSD Levels**	**Year 5 DSD Levels**
Burn Pile Footprint w/ Road Access	100%	-20%	-40%	1.68	1.34	1.01
Burn Pile Footprint w/o Road Access	100%	-10%	-20%	**1.68**	**1.51**	**1.34**
Landing Processing Area	60%	-40%	-70%	**6.06**	**3.64**	**1.82**
Temporary Roads	100%	-20%	-30%	**2.69**	**2.15**	**1.88**
Skid Trails	40%	-20%	-40%	**3.74**	**2.99**	**2.24**
Dispersed	3%	-0.1%	-0.2%	**2.32**	**2.30**	**2.27**
				16.49	**11.08**	**9.55**

Soil Design Features

Mitigation and restoration activities, where needed, should be designed to directly address the underlying source or types of ground disturbance, physical, chemical, and/or biological, that are reducing site productivity. Those activities should be targeted so as to not create unnecessary mitigation or restoration caused ground disturbance beyond what is needed to meet desired management objectives, i.e.: do no harm.

Ground-based Harvesting

- Ground-based harvesting and skidding equipment in areas of volcanic ash capped soils (ash thickness of four inches or more, starting from the mineral soil surface) should only operate on sustained slopes of 35% or less due to the highly erosive nature of un-weathered, volcanic ash in this area. Short sections of steeper slope up to a total length of 100 feet and a maximum slope gradient of 40% may be crossed, however, to reach merchantable timber and no other reasonable access route exists. Areas of volcanic ash soils for all of Priority Area One have been mapped by the Forest Soil Scientist at a 1:24,000 scale to assist project implementation and the final map digitized into Arc Map with both paper and electronic versions.
- In all other areas where surface soil horizons are not comprised of volcanic ash (see map results), ground-based harvesting and skidding equipment may operate on slopes up to a maximum gradient of 40%. Short sections (100 feet or less) of slightly steeper slopes, may be crossed however, up to a maximum slope steepness of 45%, if needed to nearby pockets of merchantable timber where no other reasonable access route exists.
- Require a systematic skid trail pattern during logging, that maintains an average spacing of 75 feet between skid trails in partial harvest units and an average spacing of 100 feet between skid trails in clearcut harvest units. Skid trail may be closer than this spacing where converging so long as overall spacing averages 75 and 100 feet, respectively.
- When reasonable, avoid placing skid trails or temporary roads over convex knobs or along narrow, rocky ledges. These areas although frequently armored with surface rock, are often the least able to recover from soil disturbance.

Treatment Unit/Burn Pile Size Limitations

- The minimum treatment unit size for all commercial thinning or clearcutting units, where whole-tree yarding will be used, will be 10 acres to ensure compliance with the Region One Soil Quality Standards. This minimum does not apply to less impactive management activities such as single tree or group selection harvests, aspen treatments or prescribed burning and may be modified where needed within the WUI through consultation with the Forest Soil Scientist.

- Avoid, to the extent reasonable, the use of ground-based harvesting equipment on convex slopes in areas of volcanic ash soils, especially along at the head of escarpments. These areas have very rocky, shallow soils, that are readily disturbed and difficult to restore.

- Ground-based skidding and harvesting equipment may be used off skid trails but only to the extent needed to harvest the available timber based on the judgement of the timber sale administrator and only when soil conditions in the top six inches of mineral soil are sufficiently dry to not create excessive soil resource damage. The Forest Soil Scientist will be available for field assessments of soil conditions whenever questions arise. Criteria used integrate soil texture and soil moisture effects. *See USDA Technical Guide for Estimating Soil Moisture (USDA-NRCS 1998).* Repeat passes over the same ground should be minimized in dispersed harvesting areas.

Skid Trails and Timber Processing Areas at Landings

- All skid trails, temporary roads, and timber processing areas at landings will be shallow ripped (maximum depth of 3 to 4 inches) in areas where obvious soil compaction or rutting has occurred resulting from heavy, ground based equipment use. This provision may be waved in portions of the affected area where very rocky soil conditions exist within 6 inches of the mineral soil surface or in areas where only limited evidence soil compaction exists. Note: Very rocky soil conditions considered to exist are present when the top six inches of mineral soil contains more that 40% rock fragments by volume that are one inch or more in diameter or where more than 60% of the soil surface is covered by rock fragments of any size.

Burn Pile Footprints

- A portion of all large burn pile footprints will be treated after pile burning, using a modified scarification approach that removes wood ash over portions of the exposed burn pile area (those areas not covered by large partially burned logging slash) after pile burning. Those islands of exposed mineral soil within the burn pile footprint will then be raked, either by hand or by using ground-based equipment, with a set of sharp teeth *(approach consistent with the Soil Science Society of America definition of scarification)*. Target levels for wood ash removal will 40 to 50% of the exposed burn pile footprint (defined above) after pile burning has been completed where system road access exists and 20 to 30% of the exposed burn pile footprint in areas where road access will be closed prior to pile burning. Initial soil restoration treatments will be followed by appropriate re-vegetation management activities, as needed, to establish desired native plant species, over those portions of the burn pile footprint treated. Soils will be directly involved with this work.

Landings

- Prioritize the siting of landing locations, where reasonable, to low slope forested areas, pre-existing road prisms or other previously disturbance areas, and/or adjacent to Forest Service roads.

Temporary Roads

- Utilize pre-existing, old temporary or jammer road prisms, if they exist, in lieu of building new temp. roads, where feasible.

- Selective re-contouring of cut and fill slopes along temporary roads will be conducted at the completion of temporary road use. Road segments identified for re-contouring will be based on critical resource needs and road suitability for re-contouring. Modified versions of partial re-contouring will be considered if warranted by special circumstances.

Coarse Woody Debris

- In all commercial timber harvest units, a minimum of 7 to 15 tons per acre of coarse woody debris (CWD) will be retained where available, in accordance with direction provided in the R-1 Supplement No. 2500-99-1 to the Forest Service Manual (USFS-R1 1999), Graham, et.al. 1994 and the 1993 Wildlife Snag Amendment to the Current Gallatin National Forest Plan (USFS-GNF 1993). Coarse woody debris are defined as any woody residue (down trees, logs, cut stumps, tree tops or large branches) greater than 7.5 cm (3 inches) in diameter that remain within treatment units after timber harvesting has been completed. To be most effective from a soil resource and erosion control perspective, CWD left in the stand should be reasonably well distributed within individual treatment units and have good contact with the ground surface. The lower level of the CWD, noted above, is based on recommended CWD levels for the subalpine fir/dwarf whortleberry habitat type in Graham, et.al. (1994).

  When sufficient available coarse woody material is not present within a treatment unit, the purchaser shall, “where available”, return unmerchantable material from the landing area and disperse it inside the cutting unit as directed by the Forest Service, to compensate for CWD not available in the stand.

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Erosion Control Seeding and Alternative Re-vegetation Strategies

- Revegetate areas of concentrated ground disturbance where mineral soil has been exposed at the surface due to the combined effects of project implementation, mitigation and/or restoration activities. Seed those areas of ground disturbance along skid trails, temporary roads, and within the timber processing portion of landings, unless an alternative revegetation strategy has been planned by the Forest Service. Seeding should occur after all timber management and initial mitigation activities have been completed. In all areas to be seeded, mineral soil should be exposed at the soil surface raked prior to seeding using an implement with sharp teeth or a comparable alternative approach that both loosens and adds roughness to the surface.

  An appropriate native seed mix will be used that is either provided by or approved by the Custer-Gallatin National Forest. Species seeded should be well suited to local site conditions and compatible with the existing native vegetation found in the local area. Either broadcast or drill seeding may be used, so long as good soil-seed contact can be established. *Note: There may be instances where natural recovery or other revegetation strategies will be a preferred alternative to seeding to meet vegetation management goals based on local soil, site, and plant community characteristics.* Such alternatives should be considered where feasible.

- Winter Harvesting

  It is assumed winter harvesting will not be used for this project due to the potential conflicts between winter harvesting activities and high levels of recreation use during the winter within the project area, based on comments made by Brian Thompson, Recreation Forester for the Hebgen District, during the initial IDT field review.

Consistency with Relevant Laws, Regulations, and Policy

National Environmental Laws

- The Multiple Use Sustained-Yield Act of 1960 – Indicates that "a high level of annual or regular periodic output of **renewable** resources will be produced on National Forest lands" while also specifying the that "coordinated management of resources will be utilized **without impairment of the productivity of the land**."

- Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 and the National Forest Management Act (NFMA) of 1976 both state "…substantial and **permanent impairment** of productivity **must** be avoided."

- Forest Service Manual, Chapter 2550 – Soil Management 2009 and 2010 amendments directs the Washington Office Director of Watershed, Fish, Wildlife, Air, and Rare plants to "coordinate validation of soil quality criteria and indicators with Forest Service Research and Development Staff to ensure soil quality measurements are appropriate to protect **soil productivity."**

- Washington Office Direction

  "Coordinate validation studies of sol quality criteria and indicators with Forest Service Research and Development to ensure soil quality measurements are appropriate to protect **soil productivity**. This document also defines **Permanent Soil Impairment.** as: "Detrimental changes in soil properties (physical, chemical, or biological) that result in the loss of inherent ecological capacity or hydrologic function of the soil resource that lasts beyond a silvicultural rotation or land management period."

Regional Direction

- Forest Service Northern Region Supplement to Forest Service Manual directs land managers to "design new activities that do not create detrimental soil conditions on more than 15% of an activity area' and that "research guidelines such as those contained in Graham et. al. 1994" for coarse woody debris "should be used if more specific local guidelines are not available". It also reiterates direction in the National Forest Management Act to "manage National Forest System lands under ecosystem management principles without permanent impairment of land productivity…"

- The Forest Service Northern Region Approach to Soils Environmental Analysis Regarding Detrimental Soil Disturbance in Forested Areas: provides technical guidance covering a wide range of issues on how detrimental soil disturbance standards are to be applied in environmental analysis of timber harvesting activities in forested areas of National Forests in Region One.

- The Forest Service Northern Region Supplement 2550-2014-1 to the Forest Service Manual: Reinforces management direction provided in the 1999 R-1 Supplement 550-99-1 while adding new direction with respect to the use of site-specific selection of indicators for soil monitoring based on local soil and site conditions. This supplement also recognizes that inherent properties of the existing soil resource, prior to ground disturbance, play a major role relative to the severity and extent of ground disturbance likely to be created by management activities.

- Forest Plan Direction: The NEPA analysis for the South Plateau project is currently scheduled for completion prior to the release of the Updated Forest Plan for the Custer Gallatin National Forest. As such, this the South Plateau Project will fall within the purview of the old Gallatin National Forest. Direction in this outdated Forest Plan is essentially silent in regard to the protection of soil resources but does address land productivity: "All management practices will be designed or modified as needed as necessary to maintain land productivity…"

Thus, at every level, National Environmental Laws, Washington Office Direction, Regional direction, and Forest Plan direction, the protection of land productivity remains at the forefront of National Forest direction with respect to the management of soil and land resources. Permanent Soil Impairment is not allowed. Relative to the South Plateau Timber and Fuels Project, I would interpret this to mean the Forest needs to adopt an appropriate and viable strategy for at least establishing a beachhead toward restoring large burn pile footprints associated with whole tree yarding back to a productive state.

Conclusion

The proposed Action Alternative has a number of positive benefits for the American public including a reduced potential for extreme wildfire behavior west of both Yellowstone National Park and the town of West Yellowstone, the utilization of timber resources, and forest health benefits, specifically the control of likely future bark beetle infestations as well as the reduction of future dwarf mistletoe damage in lodgepole pine stands. Although there is no doubt about potential benefits, the real crux of the issue from a soil resource perspective is can those benefits be achieved without creating substantial adverse effects to the local soil resource which is both fragile and the sole source of land productivity in the South Plateau area.

The concept of detrimental soil disturbance (DSD) as well as the R1 detrimental soil disturbance maximum standards (USFS-R1 1999), were created to meet the intent of National Environmental Laws, not vice-versa. Since the inception of the DSD Standards, Region One, individual National Forests in Region One and General Counsel for the Forest Service have defended these standards against numerous legal challenges with respect to their efficacy to protecting soil and land resources. Implicit in the DSD standards is an underlying assumption that ground disturbance within activity areas where those standards are apply is largely dispersed within the area of analysis. Specific exclusions where included in the R1 Supplement (USFS-R1 1999) for intensively developed sites such as mines, developed recreation sites administrative sites, or rock quarries; management areas that by their very nature create large areas of substantial

ground disturbance and where vegetation and where vegetation and water resource management are not the principal objectives.

Nowhere in the DSD Standards is there an exclusion for large contiguous areas of detrimental soil disturbance associated with vegetation management that cannot or will not be adequately mitigated on at the completion of timber management activities and are clearly outside the intent of National Environmental Laws intended to protect National Forest Lands.

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